Fishery Data Series No. 92-8

Studies of Lake Trout in Sevenmile Lake and the Tangle Lakes during 1991

by

John M. Burr

March 1992

Alaska Department of Fish and Game

Division of Sport Fish

FISHERY DATA SERIES NO. 92-8

STUDIES OF LAKE TROUT IN SEVENMILE LAKE AND THE TANGLE LAKES DURING 1991[1]

By

John M. Burr

Alaska Department of Fish and Game
Division of Sport Fish
Anchorage, Alaska

March 1992

[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-7, Study R, Job No. 3-3(a).

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Lake trout were sampled from Sevenmile Lake and the Tangle Lake system during 1991. The estimated size composition of lake trout from Sevenmile Lake contains no lake trout larger than 550 millimeters of fork length and most fish were 450 millimeters or smaller. Growth of lake trout from Sevenmile Lake estimated from mean length at age was initially fast to about age 5 or 6 (age at maturity) after which annual growth was minimal. Growth of lake trout was slower in Landlocked Tangle Lake, but maximum length was similar to lake trout from Sevenmile Lake. Though slower than fish from Sevenmile Lake, growth of lake trout in the interconnected Tangle Lakes continued to larger size (800 millimeters). Spawning lake trout were captured between 16 September and 3 October in Sevenmile Lake, Landlocked Tangle Lake, Round Tangle Lake, and Lower Tangle Lake. The number of lake trout encountered at spawning sites in the Tangle Lake system was low relative to Sevenmile Lake.

Abundance of lake trout in Sevenmile Lake was estimated for 1990 and 1991. Abundance of lake trout 250 millimeters and larger in 1990 was estimated to be 1,703 fish (SE = 226; 51.6 fish per hectare). Estimated abundance of lake trout of mature size in 1990 was 1,084 fish (SE = 175; 32.8 fish per hectare). In 1991, estimated abundance of lake trout of mature size was 505 fish (SE = 73). Density of mature fish in 1991 was estimated at 15.3 fish per hectare. The estimate of abundance for lake trout from 1990 is believed to be biased due primarily to tag loss and the estimate for 1991 is believed to more accurately reflect population size.

Results of a mail survey indicated that 31.4% of the lake trout reported in the 1990 Statewide Harvest Survey for the Tangle Lake system in 1989 actually came from other lakes, were caught and released, or were species other than lake trout. A decrease in the estimated harvest from 478 lake trout (SE = 123) as reported earlier to 328 lake trout (SE = 95) is suggested by these data.

KEYWORDS: Lake trout, *Salvelinus namaycush*, population abundance, age, growth, length, harvest, spawning, Sevenmile Lake, Tangle Lakes, harvest survey.

INTRODUCTION

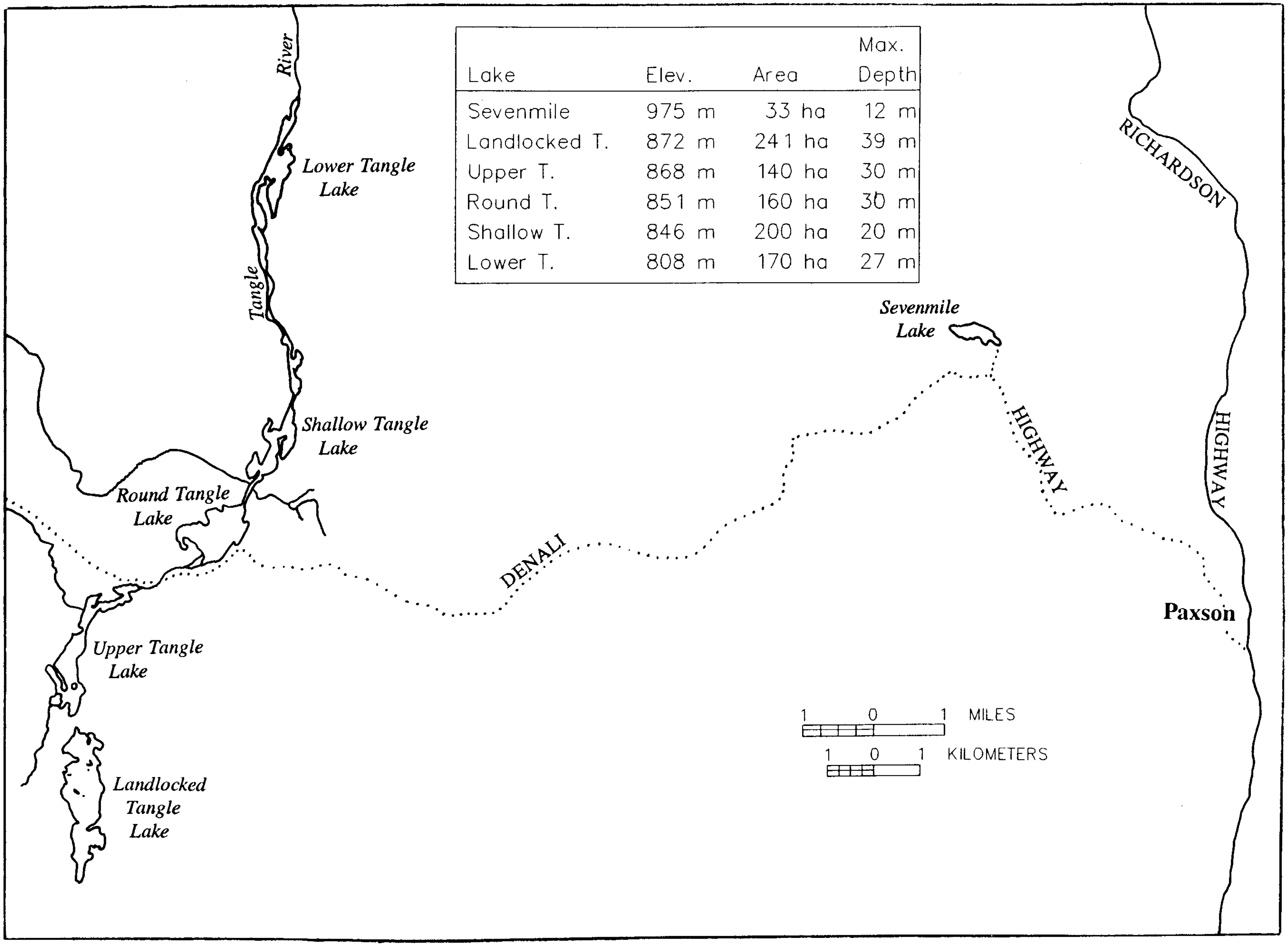
Most lake trout *Salvelinus namaycush* harvest (57%) within the Arctic-Yukon-Kuskokwim (AYK) fisheries management area occurs in the Tanana River drainage. Within this drainage, approximately 55% of the lake trout harvested comes from lakes accessible from the road system near Paxson, Alaska (Mills 1991). During 1991, data were collected from populations of lake trout from five lakes in the Tanana River drainage of central Alaska: Sevenmile Lake, and four of the Tangle Lakes. The lakes studied ranged widely in size from Sevenmile Lake (surface area 32 ha) to Landlocked Tangle Lake (surface area 241 ha; Figure 1). All five lakes are located in the Alaska Mountain Range at elevations ranging from 810 to 975 m, within alpine tundra/scrub birch habitat.

Sevenmile Lake is located at an elevation of 975 m and the lake is adjacent to the Denali Highway (Figure 1). The estimated surface area of the lake is 33 ha and the maximum recorded depth is 12.5 m. There are no active inlet or outlet streams, so it is closed to immigration and emigration. Fish species present include lake trout, slimy sculpin *Cottus cognatus*, and burbot *Lota lota*.

Sevenmile Lake was originally selected for study because of the good access and the apparently dense population of small lake trout. The lake is considered typical of many of the small oligotrophic lakes in the area with low species diversity, and a population of planktivorous/benthivorous lake trout. The good access has resulted in substantial angling effort and harvest. This has provided an opportunity to investigate sustainable yield and the effects of fishing on growth and maturity. The population of lake trout has been sampled annually since 1986, providing a valuable time series data base. Estimates of abundance have been conducted since 1987. In addition to other population characteristics, data was wanted concerning the timing and location of spawning in Sevenmile Lake. This population is being considered as a lake trout brood source for use in the stocking of small lakes along the road system in the Tanana drainage.

The Tangle Lakes are located at the head of the Delta River system and are composed of a series of small lakes connected by the Tangle River (Figure 1). Landlocked Tangle Lake is unique in that it is isolated from the remainder of the lake and stream system. Fish species composition in Landlocked Tangle Lake is limited to lake trout, round whitefish *Prosopium cylindraceum*, slimy sculpin, and burbot. Two additional species are present in the connected Tangle Lakes, Arctic grayling *Thymallus arcticus* and longnose suckers *Catostomus catostomus*. The longnose suckers are most abundant in Upper Tangle Lake. Round whitefish and Arctic grayling are distributed throughout the interconnected lake and stream system.

In contrast to Sevenmile Lake, population density of lake trout in the Tangle Lakes is low, particularly in the lakes adjacent to the road and campgrounds. This is a popular recreation site for anglers from urban centers to the south and north. Prior to 1987, harvest of lake trout in the Tangle Lakes increased to levels which were likely unsustainable. Healey (1978) suggested that average yields of lake trout greater than 0.5 kg/ha/yr are excessive. In



Lake	Elev.	Area	Max. Depth
Sevenmile	975 m	33 ha	12 m
Landlocked T.	872 m	241 ha	39 m
Upper T.	868 m	140 ha	30 m
Round T.	851 m	160 ha	30 m
Shallow T.	846 m	200 ha	20 m
Lower T.	808 m	170 ha	27 m

Figure 1. Map of study area near Paxson, Alaska with elevation, surface area and maximum depth of each lake.

1987, regulations were adopted which reduced the daily bag limit from 12 to one lake trout per day and limited harvest to fish 18 inches of total length (TL) and larger. These management actions were aimed at limiting lake trout harvest to the yield guideline suggested by Healey. In 1989, estimated harvest of lake trout once again exceeded the 0.5 kg/ha guideline. It was suspected, based on personal communications with fishermen, that some portion of the harvest reported as lake trout from the Tangle Lakes was actually coming from lakes not within this lakes system. To test this hypothesis, a survey was conducted of anglers from which the estimated harvest in 1989 was based.

Stock assessment in the Tangle Lakes system has been frustrated by the diversity of the system and the low abundance of lake trout within the system. Standard sampling techniques have resulted in unacceptably high sampling mortality (>10%). Past experience at other lakes in Alaska has shown that large numbers of lake trout may be sampled during the fall as the fish concentrate for spawning. Sampling effort in 1991, therefore, focused on the probable spawning season with the goal of locating spawning areas, determining timing of spawning, and sampling a significant portion of mature lake trout from the lakes within the system.

The specific objectives during the 1991 field season were to:

1. estimate population abundance of lake trout greater than 249 mm fork length (FL) in Sevenmile Lake;

2. estimate length composition of lake trout greater than 249 mm fork length (FL) in Sevenmile Lake;

3. estimate mean length at age for populations of lake trout in Sevenmile Lake and the Tangle Lakes;

4. determine if identified potential spawning sites in Sevenmile Lake and the Tangle Lakes are active spawning locations; and,

5. estimate the proportion of the lake trout harvest from the Tangle lakes reported in the Statewide Harvest Survey in 1989 which actually came from other nearby waters.

This report is divided into four sections. In the first section, estimates of lake trout abundance in Sevenmile Lake during 1990 and 1991 are presented. This is followed by information on the size composition and length at age for lake trout from Sevenmile Lake and length at age for lake trout from the Tangle lakes. Next, results of sampling during the spawning season in the Tangle Lakes system and in Sevenmile Lake are presented. Lastly, the information gathered from a survey of anglers which reported harvesting lake trout in the Tangle Lakes is given.

POPULATION ABUNDANCE ESTIMATE, SEVENMILE LAKE

Methods

A mark-recapture experiment was conducted to estimate the population abundance of lake trout larger than 249 mm of fork length (FL) in Sevenmile Lake during 1990 and 1991. A modified Petersen mark-recapture estimator was selected (Chapman 1951) with marking events and recapture events performed in separate years (Seber 1982). The marking event was conducted in 1990 and the recapture event was performed in 1991. The Petersen estimator was selected because it was believed to be feasible to adjust for potential growth recruitment in this otherwise closed population. The estimated abundance is germane to the time of marking. Population abundance and the approximate variance of this estimate was calculated with the following formulas (Seber 1982):

$$\hat{N} = \frac{(C+1)(M+1)}{(R+1)} - 1 \qquad (1)$$

$$V[\hat{N}] = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)} \qquad (2)$$

where:

M = the number of lake trout marked during the marking sample period;

C = the number of lake trout captured during the recapture sample period; and,

R = the number of lake trout captured during the recapture period with marks from the marking period.

Assumptions for the accurate use of the Petersen mark-recapture estimator include (Seber 1982):

1. the population is closed (no change in the number of lake trout in the population during the experiment);

2. all lake trout have the same probability of capture in the marking sample <u>or</u> in the recapture sample, <u>or</u> marked and unmarked lake trout mix completely between marking and recapture events;

3. marking of lake trout does not affect their probability of capture in the recapture sample;

4. lake trout do not lose their mark between the marking and recapture events; and,

5. all marked lake trout are reported when recovered in the recapture sample.

Efforts were made to meet these requirements. To promote mixing of marked fish with the unmarked population, marked fish were released throughout the lake. Since one year lapsed between the capture events it is reasonable to expect that mixing of marked and unmarked fish occurred. To measure tag loss, all fish were given a left pectoral fin clip as well as a uniquely numbered tag. From 1987 through 1990, adipose fins were removed as a second mark. To minimize differential mortality between marked and unmarked fish, only fish which appeared to be in good condition were released. Handling induced "net shyness" should have been minimized by the period of time between the marking and recapture events.

Growth recruitment in this lake trout population was considered likely between the marking and recapture events. The Petersen estimator is valid for multi-year experiments if either mortality or recruitment (but not both) occurs between sampling events (Seber 1982). To evaluate recruitment through growth between the marking period and the subsequent recapture period, a nonparametric method of testing for recruitment was used (Robson and Flick 1965). When growth recruitment was found, the length beyond which no significant growth recruitment is detectable (L_r) was determined and separate estimates of abundance for each portion of the population were made. The abundance of fish larger than L_r was calculated with the Petersen estimator. The abundance of fish below L_r was calculated with the model from Robson and Flick (1965):

$$\hat{N} = (m + 1)(\bar{u}_r) - 1 \quad \text{and,} \tag{3}$$

$$V[\hat{N}] = (m + 1)^2 \, V[\bar{u}_r]; \tag{4}$$

where:

$\hat{N}$ = estimated abundance of lake trout smaller than the upper extent of growth recruitment (L_r);

m = number of marked lake trout from the marking period that were smaller than the upper extent of growth recruitment (L_r); and,

$\bar{u}_r$ = frequency of unmarked lake trout averaged over the cells formed by the fish recaptured in the recapture period beyond the upper extent of growth recruitment (L_r).

The variance of $\bar{u}_r$ was calculated using standard normal procedures to find the variance of a mean over the u_i where i is from r to M.

The Jolly-Seber model (Seber 1982) was also used for estimating the abundance and survival of lake trout 249 mm and larger in Sevenmile Lake in 1989 and 1990. This model allows for immigration and mortality. The multi-year design promotes mixing of marked and unmarked fish. The estimated abundance provided by the Jolly-Seber model was compared with the results from the Petersen estimator and the more precise and least biased estimate was then selected. The number of lake trout marked in 1989 and surviving to 1990 was estimated by:

$$\hat{M}_{89,90} = \frac{R_{89,91}M_{89}}{R_{90,91}} + R_{89,90} + D_{89,90} \qquad (5)$$

where:

$\hat{M}_{89,90}$ = estimated number of marked lake trout released alive into the population in 1988 and still alive just prior to sampling in 1989;

M_{90} = number of marked lake trout released alive in 1989;

$R_{89,90}$ = number of marked lake trout released in 1988 and recaptured in 1989;

$R_{89,91}$ = number of marked lake trout released in 1988 and recaptured in 1990;

$R_{90,91}$ = number of marked lake trout released in 1989 and recaptured in 1990; and,

$D_{89,90}$ = number of marked lake trout released in 1988, recaptured during 1989, and not returned to the population (usually due to death).

An estimate of the survival rate between 1989 and 1990 was then calculated as:

$$\hat{S}_{89,90} = \frac{\hat{M}_{89,90}}{M_{89}} \qquad (6)$$

Population abundance just prior to sampling in 1990 was estimated as:

$$\hat{N}_{90} = \frac{C_{90}\hat{M}_{89,90}}{R_{89,90}} \qquad (7)$$

where:

$\hat{N}_{90}$ = estimated abundance just prior to sampling in 1990; and,

C_{90} = number of lake trout captured in 1990.

All the assumptions for the use of the Jolly-Seber method (Seber 1982) are the same as those for the Petersen mark-recapture procedure except that the population need not be closed (i.e., mortality and recruitment are permitted between sampling events). The Jolly-Seber method requires at least three sampling events and is unbiased only for situations with large overall sample sizes including large numbers of recaptured fish.

Point estimates and variances of population size and survival rate were calculated by bootstrapping the capture histories of lake trout marked in 1987 through 1990, 400 times according to the procedures of Efron (1982) and Buckland (1980, 1982).

For the mark-recapture experiment, the hypothesis of equal probability of capture during each sampling event for fish of different sizes was tested with the Kolmogorov-Smirnov two-sample test (Conover 1980) and contingency table analysis. The data were grouped by length classes for the contingency table analysis. The first test compared the frequencies of tagged fish recaptured versus those not recaptured by size group. Frequencies of fish captured during the marking event were compared with fish captured during the recapture event for the second test (Seber 1982).

To compare densities of mature lake trout from estimates which have been made, the abundance estimates were reduced by the proportion of the fish sampled which were less than the estimated length at which 50% of the fish are mature (LM_{50}). The proportion of mature fish in each sample was estimated as follows:

$$\hat{p}_j = \frac{n_j}{n}; \text{ and,} \tag{8}$$

$$V[\hat{p}_j] = \frac{\hat{p}_j(1-\hat{p}_j)}{n - 1}; \tag{9}$$

where:

n_j = the number of lake trout in the sample from group j;

n = the sample size; and,

p_j = the estimated fraction of the population of lake trout that is made up of group j.

The estimated abundance and variance of mature fish was calculated as follows (Goodman 1960):

$$\hat{N}_m = \hat{p}\,\hat{N}; \text{ and,} \tag{10}$$

$$\hat{V}[\hat{N}_m] = \hat{p}^2\, \hat{V}[\hat{N}] + \hat{V}[\hat{p}]\, \hat{N}^2 - \hat{V}[\hat{p}]\, \hat{V}[\hat{N}]; \tag{11}$$

where:

$\hat{N}$ = estimate of abundance of lake trout;

$\hat{N}_m$ = estimate of abundance of lake trout of mature size; and,

$\hat{p}$ = estimate of the proportion of mature fish in $\hat{N}$.

In 1987, a mark-recapture experiment was conducted to estimate abundance of lake trout larger than 249 mm FL in Sevenmile Lake (Burr 1988). Beginning in 1988, lake trout have been sampled annually during July or August with the goal of estimating lake trout abundance (Burr 1989, 1990, 1991a). Between 7 and 14 August, 1991, lake trout were captured with 51 mm (stretch measure) x 3 m x 46 m sinking gill nets, baited hoop nets, and fyke nets. In addition, lake trout were captured with gill nets on 10 and 16 September. Gill nets were checked at intervals of one half hour or less. The hoop nets were baited with cut Pacific herring *Clupea harengus* which was placed in perforated bait containers. These nets were set in all parts of the lake at various depths ranging from 1 to more than 12 m. Fyke nets were set near shore at depths of about 1.2 m with center lead nets attached to shore.

Results

Three estimates of abundance were calculated for lake trout in Sevenmile Lake: two for 1990 and one for 1991. The modified Petersen estimate for 1990 utilized data collected in 1990 and in 1991 while the estimate using the Jolly-Seber model utilized data from 1989, 1990, and 1991. The modified Petersen estimate for 1991 utilized 1991 data only.

Lake Trout Abundance 1990 - Petersen Estimate:

The abundance of lake trout larger than 250 mm FL in Sevenmile Lake at the end of sampling in 1990 was estimated to have been 1,703 fish (SE = 266; Table 1). The estimated density was 51.6 lake trout per hectare (20.9 lake trout/acre). The estimate of the abundance of lake trout of mature size (LM_{50} and larger) in Sevenmile lake in 1990 was 1,084 fish (SE = 175); density was estimated to have been 32.8 mature lake trout per hectare (13.3 lake trout/acre; Table 1).

During sampling in 1990, 247 lake trout 250 mm (FL) or larger were marked in Sevenmile Lake. Of these 247 lake trout, 245 were caught in gill nets, the remaining two fish were caught in hoop nets (Appendix A1). During 1991, 355 lake trout 250 mm (FL) and larger were captured; 352 in gill nets, two in hoop nets, and one in a fyke net (Appendix A2). Thirty-two of the 356 lake trout were recaptured from the fish marked and released with tags in 1990. In

Table 1. Estimated abundance of lake trout larger than 250 mm FL in Sevenmile Lake in 1990.

Strata	Number of Lake Trout			$\bar{u}_r$[a]	Abundance Estimate	SE	Lake Trout per Hectare
	Marked	Recaptured	Examined				
250 - 389 mm	83	2	136	8.1	745	27	22.6
> 389 mm	164	30[b],37[c]	220		959	123	29.1
Total	247	32	356		1,703	266	51.6
LT > LM_{50}[d]					1,084	175	32.8

[a] Average number of unmarked to marked lake trout 390 mm FL and larger in 1990.

[b] Number of lake trout captured with tags from 1990.

[c] Number of lake trout captured from 1990 after adjustment for tag loss, see Appendix A4.

[d] The length at which 50% of lake trout of both sexes are mature, LM_{50} = 386 mm FL.

addition, absence of adipose fins from lake trout captured in 1991 indicated that 41 lake trout had shed tags which were inserted in either 1987, 1988, 1989, or 1990. It was not possible to determine if these fish were originally marked in 1990 or in a previous year. Annual tag loss for lake trout in this population was estimated to be 19.35% in 1988 (Burr 1991a, Appendix A3). To correct for tag loss, the number of recaptures (32) was increased by 19.35% to 40. Three-hundred-nine lake trout were captured alive, tagged if not previously tagged, and released in 1991. Forty-six lake trout died in the sampling gear.

Comparison of lengths of fish marked in 1990 with lake trout recaptured in 1991 failed to detect any difference in the distribution of lengths (K-S Two Sample Test; DN = 0.19, P = 0.25; Appendix A4). In addition, comparison of lengths of all fish captured in 1990 with fish captured in 1991 failed to show any difference between the two samples (K-S Two Sample Test; DN = 0.09, P = 0.17; Appendix A4). Hence, no size selectivity in either sampling event was detected. Hypothesis tests to detect size selectivity may not be effective when there is a long hiatus between sampling events. As a result, examination of length distributions of fish captured in 1990 (marking event) with fish captured in 1991 (recapture event) may not provide needed information on gear selectivity. In an additional effort to detect size selectivity in the samples, the lengths of fish marked in August 1991 and recaptured in September 1991 (Appendix A5) were compared. A significant difference was not detected for fish 370 mm and larger (K-S Two Sample Test; DN = 0.19, P = 0.4). No lake trout less than 370 mm FL were recaptured from fish marked in August. Similarly, comparison of lengths of all fish larger than 370 mm captured in August 1991 and in September 1991 failed to show any difference between the two samples (K-S Two Sample Test; DN = 0.14, P = 0.25). Hence, no size selectivity was indicated in the 1991 sample for lake trout >370 mm.

Growth recruitment likely occurred between the sampling events of 1990 and 1991. Growth recruitment was indicated by comparison of lengths of fish recaptured from 1990 with fish captured without tags from 1990 in 1991 (K-S Two Sample Test; DN = 0.40, P < 0.01; Appendix A4) and by examination of plots of these data (Figure 2). The technique of Robson and Flick (1965) indicated that the upper extant of growth recruitment was between 387 and 390 mm FL. Annual growth information of fish marked and recaptured one year later provides additional information concerning growth recruitment. Between 1990 and 1991, lake trout between 280 and 388 mm FL grew on average 31 mm while fish 395 mm and larger grew an average of 11 mm during the same period. Pooled annual growth data from 1987 through 1991 show average growth for lake trout between 200 and 388 mm FL to be 60 mm while fish 390 mm FL and larger grew an average of 10 mm (Appendix A6, Figure 3). Hence, the upper extant of growth recruitment for lake trout in Sevenmile Lake is estimated to be 389 mm FL.

To estimate population abundance for 1990, the data were divided into two strata, fish 250 mm to 389 mm and fish 390 mm and larger. Further stratification was deemed unnecessary because no size selectivity of the sampling gear was detected. An estimate of abundance of fish larger than 389 mm was obtained with the modified Petersen estimator (Table 1) with the

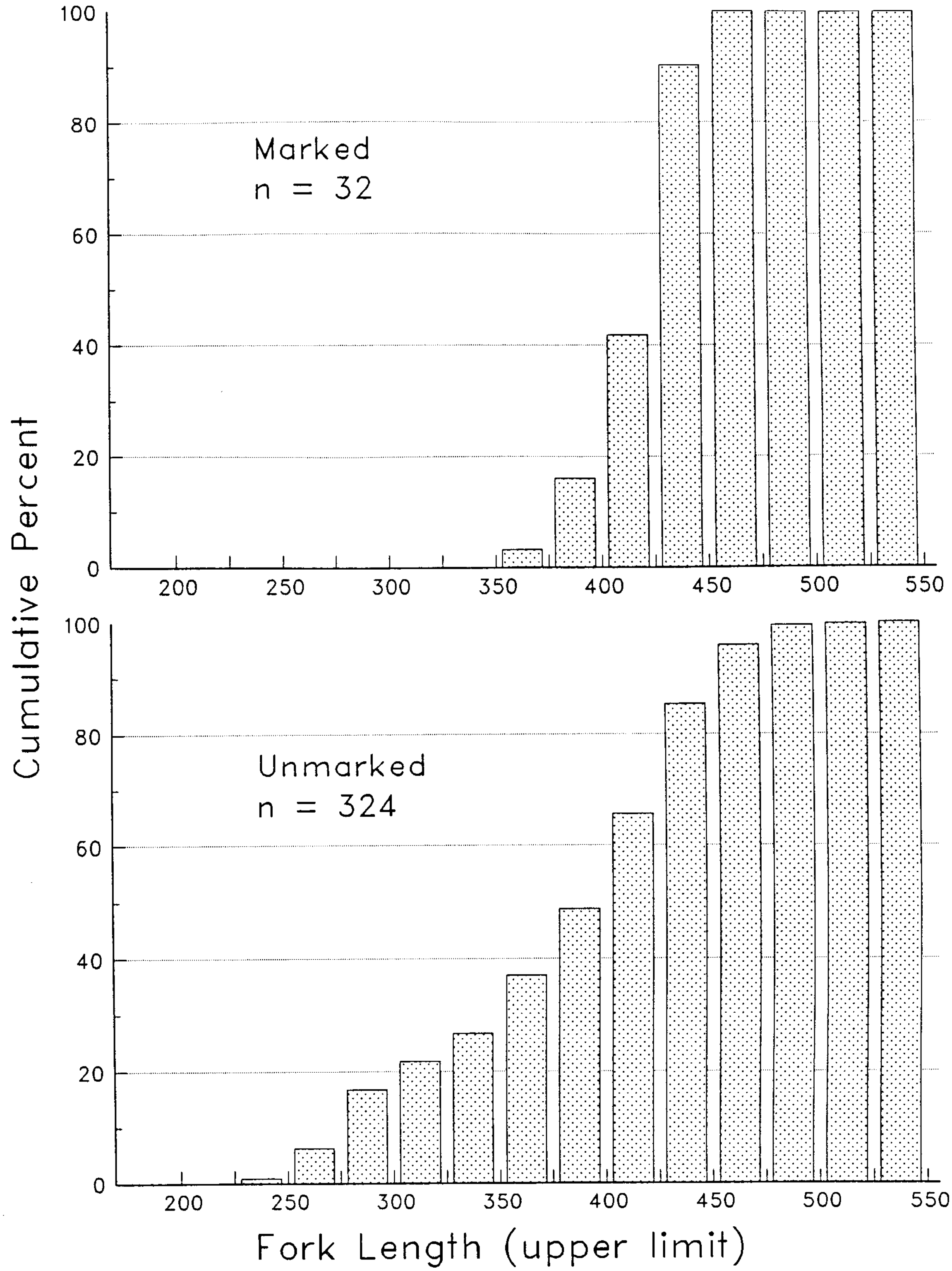


Figure 2. Cumulative distribution of lengths of marked (recaptured) and unmarked lake trout captured in 1991 from Sevenmile Lake.

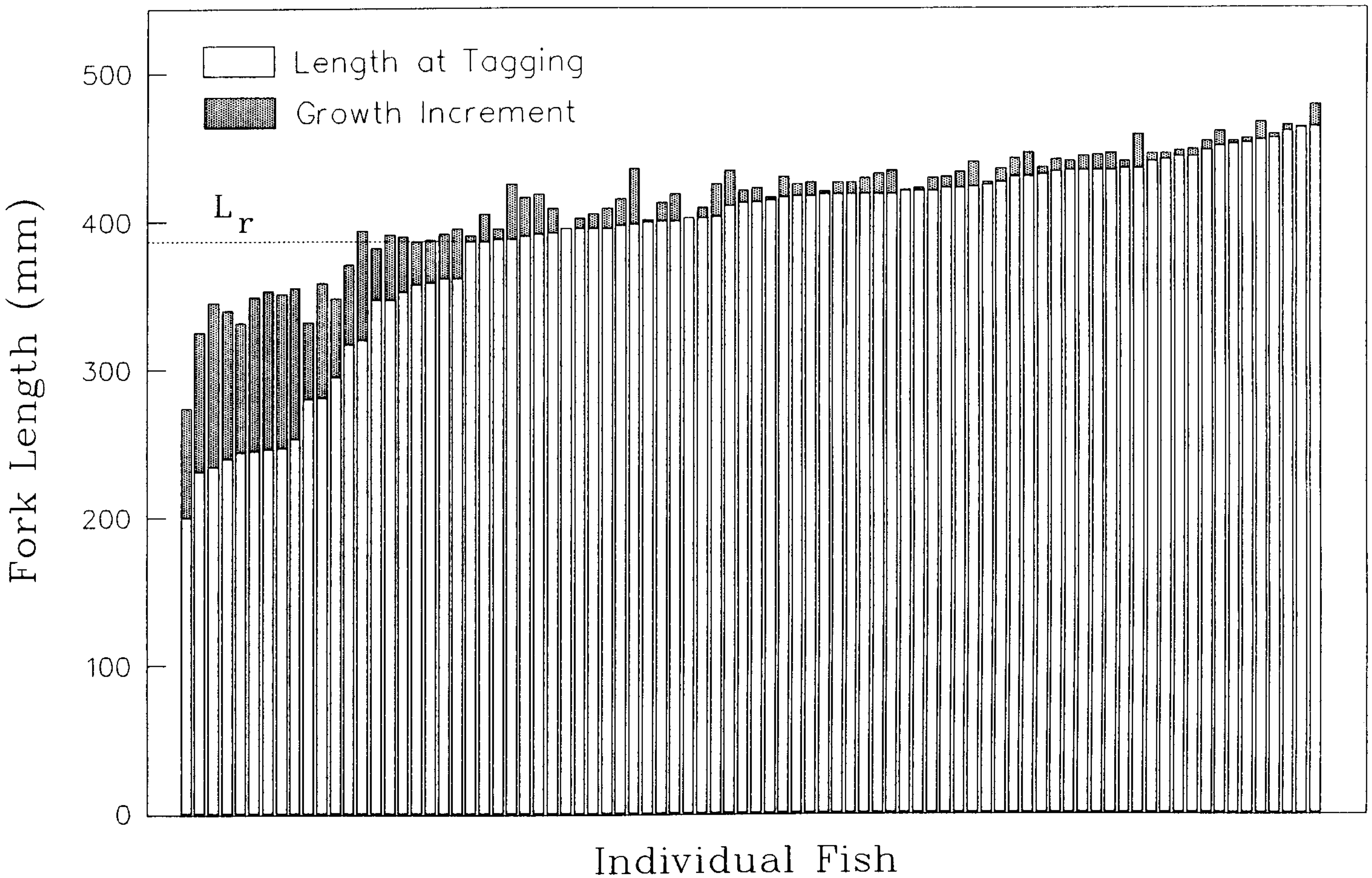


Figure 3. Annual growth of lake trout recaptured in 1987 through 1991 in Sevenmile Lake. The upper limit of growth recruitment (L_r) is indicated by broken line.

assumption that recruitment through growth for lake trout 390 mm and larger was negligible. The abundance of lake trout 250 to 389 was made after growth recruitment was removed. The abundance of fish in the smaller size category was estimated with procedures of Robson and Flick (1965).

Lake Trout Abundance 1991:

The abundance of lake trout larger than 370 mm FL in Sevenmile Lake at the end of sampling in August 1991 was estimated to have been 550 fish (SE = 79; Table 2). The estimated density was 16.6 lake trout per hectare (6.7 lake trout/acre). The estimate of the abundance of lake trout of mature size (LM_{50} and larger) in Sevenmile lake in 1991 was 505 fish (SE = 73); density was estimated at 15.3 mature lake trout per hectare (6.2 lake trout/acre; Table 2).

During sampling in August 1991, 242 lake trout 250 mm (FL) or larger were marked in Sevenmile Lake. Of these 242 lake trout, 240 were caught in gill nets, the remaining two fish were caught in hoop nets (Appendix A5). During September, 1991, 101 lake trout 250 mm (FL) and larger were captured; all in gill nets (Appendix A5). Twenty-six of the 101 lake trout were recaptured from the fish marked and released with tags in August 1991, but all were 370 mm or larger. In addition, absence of adipose fins indicated that 10 lake trout had shed tags which were inserted in either 1987, 1988, 1989, or 1990. Left pelvic fin clips were used in 1991 and no tag loss was observed between the two 1991 sampling events.

Size selectivity of the sampling gear was not detected for lake trout 370 mm and larger (see previous section). No lake trout less than 370 mm FL were recaptured from fish marked in August hence the lengths of all fish marked in August 1991 and recaptured in September 1991 were not the same (K-S Two Sample Test; DN = 0.28, P = 0.05). Similarly, comparison of lengths of all fish larger than 250 mm captured in August 1991 with lengths of fish captured in September 1991 indicated that they were not the same (K-S Two Sample Test; DN = 0.17, P = 0.02). Therefore no estimate of abundance for fish 250 to 369 mm FL was obtained. An unstratified estimate of abundance for lake trout 370 mm and larger was calculated with the modified Petersen estimator.

Jolly-Seber Estimates

The Jolly-Seber model was used with the goal of estimating recruitment and survival of lake trout from Sevenmile Lake. The model failed to provide realistic estimates of survival; survival was estimated at 100% for 1988 through 1990 (Appendix A7). Estimates of recruitment for the periods 1988 to 1989 and 1989 to 1990 were 176 fish (SE = 215) and 878 fish (SE = 351), respectively. The estimate of abundance for 1990 of 2,305 lake trout (SE = 312) 250 mm and larger is similar to the abundance estimate from the multi-year Peterson estimator (1,703 fish, SE = 266; Table 1). Because the Petersen estimate of abundance for 1990 is more precise and is less likely to be biased with the sample sizes that were attained, the Petersen estimate of abundance is preferred. The tag loss which was encountered during the sampling was not included in the Jolly-Seber model. Hence, the bias introduced by this factor

Table 2. Estimated abundance of lake trout larger than 370 mm FL in Sevenmile Lake in 1991.

Length Group	Number of Lake Trout: Marked	Recaptured	Examined	Abundance Estimate	SE	Lake Trout per Hectare
250 - 369 mm	65	0	19			
> 369 mm	177	26	82	550	79	16.6
Total	242	26	101			
LT > LM_{50}[a]				505	73	15.3

[a] The length at which 50% of lake trout of both sexes are mature, LM_{50} = 386 mm FL.

is exacerbated with each additional sampling event and estimates provided by the model are likely to be biased.

Discussion

Previous estimates of abundance of mature lake trout in Sevenmile Lake have centered on two figures; approximately 500 for 1987 and 1991 and 800 - 1,100 for 1988, 1989 and 1990 (Table 3). The estimates of abundance for 1988 and 1989 were not significantly different from the 1990 estimate ($P = 0.11$ and $P = 0.45$) or from each other ($P = 0.11$). The estimates of abundance for 1987 (459) and 1991 (505) were not significantly different from each other ($P = 0.34$) but were different from the other three estimates ($P < 0.03$). The 1987 and 1991 estimates were calculated from data collected within one season. The remaining estimates (1988-1990) were calculated from data collected over two seasons with approximately 12 months between marking and recapture. At least three factors may be responsible for the differences between the estimates obtained from the within year and the between year experimental designs. First, size selectivity of the sampling gear may have resulted in unequal probability of capture for fish of different sizes in the experiments conducted over more than one year. The power of the tests used to detect size selectivity for the multi-year experiments is low. However, the estimates considered here are for adult fish only and for fish of a relatively small range of sizes. These adult fish appear to be fully recruited to the mix of sampling gear used in each sampling event. Also, size selectivity was not detected in the within year experiments (Burr 1988 and this study). Therefore, it seems unlikely that size selectivity is responsible for bias of the magnitude indicated by the differences in the results of the two experimental designs. A second factor which might have caused the observed bias is recruitment through growth between sampling events. Growth recruitment was culled from the estimates using the technique of Robson and Flick (1965). Annual growth of recaptured fish was also used in the three estimates to more precisely determine the upper extant of growth recruitment (L_r). In each case, the estimated length above which growth recruitment was negligible was similar (389 to 399 mm). The estimated L_r is similar to the length at which 50% of fish of both sexes are mature for this population (LM_{50} = 386 mm FL). Thus, growth recruitment does not appear to be a significant factor affecting abundance estimates of lake trout of mature size. Although there is likely some level of growth recruitment within the size group under consideration, it is unlikely that unculled growth recruitment is responsible for the inflation of the three multi-year estimates. A third factor which could result in an inflated estimate of abundance in the multi-year experimental design is tag loss. The number of fish captured without floy tags but with missing adipose fins has increased annually since 1988 (Appendix A3). Adipose fins were removed as a second mark during studies conducted between 1987 and 1990. As a result, it is not possible to determine in which year a fish was marked if the floy tag is lost. Some level of tag shedding is unavoidable because gill nets are the primary gear used to capture the fish. The effect of tag loss would be to underestimate the number of marked fish resulting in overestimation of abundance. In an attempt to adjust for tag loss, the rate of tag loss between 1987 and 1988 was used to apportion the fish captured with missing adipose fins in 1991 to fish marked in 1990. Even with this adjustment, the estimate for 1990 is dissimilar from the

Table 3. Estimated abundance of mature (LM_{50} and larger) lake trout in Sevenmile Lake, 1987-1991.

Year	Sample Period: Marking	Sample Period: Recapture	Abundance Estimate	SE	Reference
1988	JUL 1988	JUL 1989	791 [a]	158	Burr 1990
1989	JUL 1989	JUL 1990	1,054	138	Burr 1991
1990	JUL 1990	AUG, SEP 1991	1,084	175	this study
1987	JUN 1987	JUL 1987	459 [b]	85	Burr 1989
1991	AUG 1991	SEP 1991	505	73	this study

[a] Estimates grouped by vertical line are not significantly different (791 vs 1,054, P = 0.11; 1,054 vs 1,084, P = 0.45; 791 vs 1,084, P = 0.17).

[b] Estimates grouped by vertical line are not significantly different (P = 0.34).

estimates obtained with the single year design. Because the estimate of annual tag loss was based on a single hiatus (1987 to 1988), it may not be representative of all years in the study. In addition, tag loss rate may not be constant for fish which have been tagged 2, 3, or 4 years. The experiment should be repeated in the upcoming season with the focus of identifying the major source of bias. The left pelvic fin was clipped in 1991 and different fin clips should be used each year to monitor tag loss rates. The same mix of gears should be used in August and in the spawning sampling in September to reduce the probability of size selectivity.

The estimates of abundance obtained from the within year design are believed to most accurately reflect true population abundance in Sevenmile Lake. Tag loss is believed to be the primary source of bias observed in the multi-year Petersen estimates of abundance. Although the estimates of abundance from the multi-year Petersen designs for 1988, 1989, and 1990 are not significantly different, they do increase each year as tag loss increases. A similar trend is observed in the abundance estimates from the Jolly-Seber model. In contrast, abundance estimated with within year data for which tag loss was accounted for did not increase between 1987 and 1991.

LENGTH COMPOSITION AND MEAN LENGTH AT AGE

Methods

Age, weight, length, sex, and maturity data were obtained from lake trout sampled from the study lakes in 1991. When a lake trout was captured in good condition, it was tagged with an individually numbered Floy anchor tag before being released. When killed by the sampling gear, lake trout were weighed and dissected to obtain otoliths for age determination and to obtain information concerning sex and maturity. These data were obtained from lake trout while conducting the abundance sampling at Sevenmile Lake and while conducting test netting at the Tangle Lakes. Length and age data were also obtained from creel sampling conducted at the Tangle lakes.

Age Determination:

All age data presented in this report are based on ages obtained from otoliths. Whole otoliths were prepared by hand grinding surfaces on a carborundum honing stone and were viewed with a compound microscope under reflected light. Sets of opaque and hyaline bands were counted as years of growth with the hyaline bands used as annuli.

Size Composition:

Estimates of the size composition of lake trout from Sevenmile Lake were obtained. The proportion of the population corresponding to various size categories were estimated with formula (8) and the variances of the proportions were estimated with formula (9); see previous section on estimation of abundance.

elative Stock Density (RSD). The RSD categories of "stock", "quality", "preferred", "memorable", and "trophy" were based on criteria provided by Gabelhouse (1984).

Size at Age:

Mean length at age was estimated from samples of lake trout collected between 1987 and 1991 from Sevenmile Lake, Landlocked Tangle Lake, Upper Tangle Lake, and Round Tangle Lake. Estimates of mean length at age were calculated with standard normal procedures. Simple averages and squared deviations from the means were used to calculate means and variances of the means.

Results

Size Composition:

The length composition of lake trout 370 mm and larger was estimated from pooled samples of fish collected in August and September, 1991. Size selectivity of the sampling gear was not detected for fish of this length and larger (see previous section on estimated abundance). Bias is suspected in the samples used to estimate abundance for 1990, so size composition was not calculated for 1990.

Lake trout inhabiting Sevenmile Lake are small. Most lake trout within the size range considered were within the stock category (453 mm FL or smaller; Table 4, Figure 4). Within this category, most fish (62%) were 400 to 453 mm. Few fish were larger and all were 550 mm less.

Size at Age:

Estimates of mean length at age were calculated for populations in Sevenmile, Landlocked Tangle, Round Tangle, and Upper Tangle lakes. Lake trout from Sevenmile Lake exhibited the fastest initial growth but growth slowed at age 5 to 6 after which annual growth was minimal (Table 5, Figure 5). Growth of lake trout was slower in Landlocked Tangle Lake (Table 6) but lengths of older fish were similar to the maximum lengths of lake trout from Sevenmile Lake. In the connected Tangle lakes (Round and Upper Tangle), young lake trout grew slower than in Sevenmile Lake but growth continued to a larger size (Tables 7 and 8; Figure 5).

Discussion

A common characteristic of these populations is the large variability in size at age, particularly for fish of adult size. For example, lake trout of about 400 mm FL in Landlocked Tangle Lake had otoliths which ranged from 11 to 26 annuli. The variability observed in lengths at age and ages at length makes estimates of the age of a particular fish from length alone unreliable.

In Sevenmile Lake and Landlocked Tangle Lake, growth of lake trout declines rapidly upon attainment of maturity for most fish. Length and age at 50% maturity (LM_{50}, AM_{50}) for female lake trout from Sevenmile and Landlocked Tangle lakes are 391 mm and 5 years and 348 mm and 10 years, respectively

Table 4. Length composition of lake trout 370 mm FL and larger in Sevenmile Lake during 1991 expressed as Relative Stock Density and in 25 mm categories.

Length Category	Number of Fish	Proportion	Stratum Error	Abundance	Standard Error
Stock (240-453 mm)[a]					
370-453 mm	209	0.816	0.024	449	66
Quality 454-545 mm	46	0.180	0.024	99	19
Preferred 546-714 mm	1	0.004	0.004	2	2
Memorable 715-894 mm	0	0	0	0	0
Trophy >894 mm	0	0	0	0	0
376-400 mm	43	0.173	0.024	95	19
401-425 mm	68	0.274	0.028	151	27
426-450 mm	86	0.347	0.030	191	32
451-475 mm	38	0.153	0.023	84	17
476-500 mm	11	0.044	0.013	24	8
501-525 mm	1	0.004	0.004	2	2
526-550 mm	1	0.004	0.004	2	2

[a] Proportion of fish 240 to 369 mm is unknown

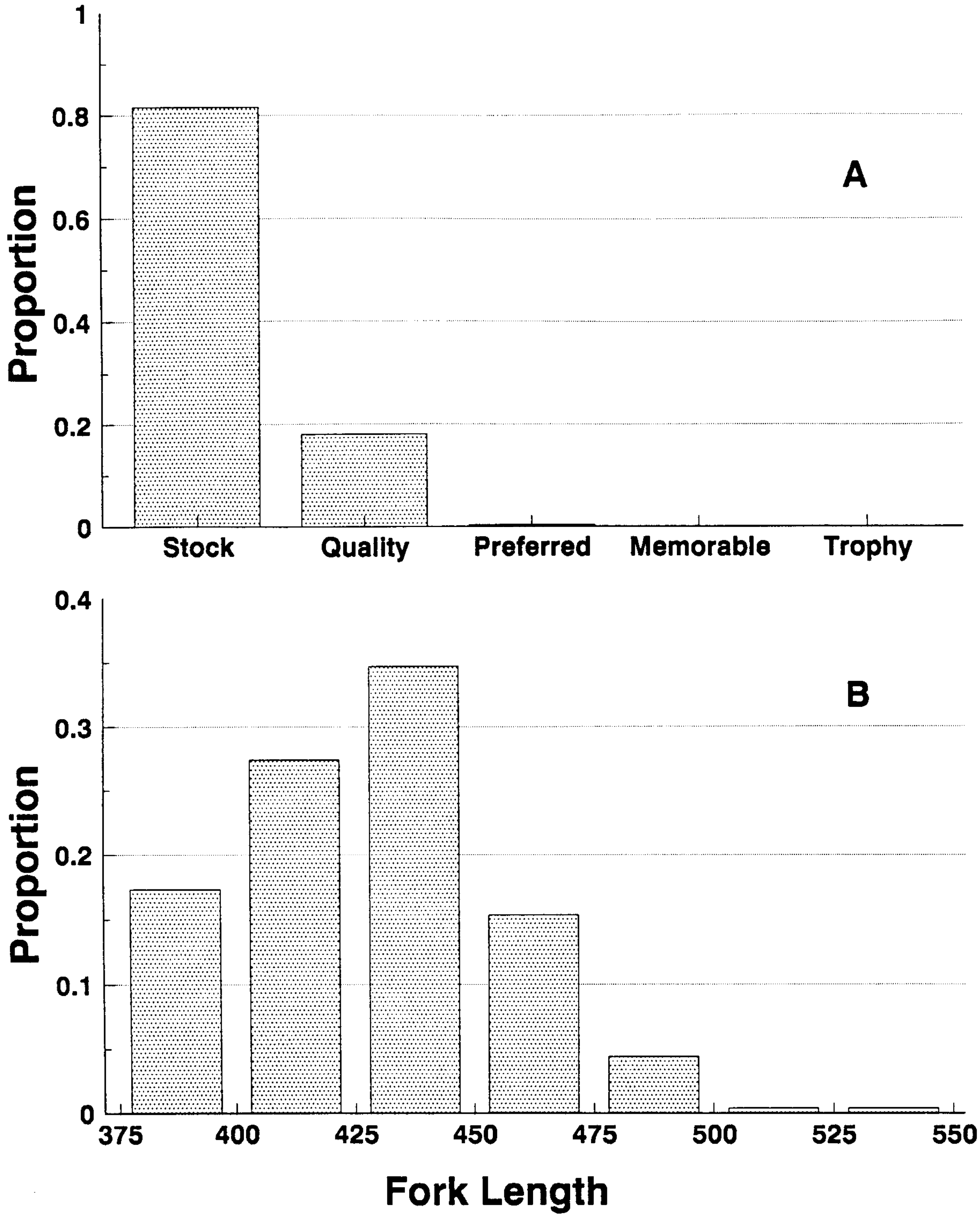


Figure 4. Length composition of lake trout from Sevenmile Lake in 1991 expressed as Relative Stock Density (Panel A) and in 25 mm length categories.

Table 5. Estimated length (mm FL) at age (from otoliths) of lake trout from Sevenmile Lake, 1987-1991.

Age	All Lake Trout			Female Lake Trout			Male Lake Trout		
	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE
0		0			0			0	
1	93	12	4		0			0	
2	212	11	15	172	2	3	231	3	25
3	297	33	4	299	14	8	293	14	5
4	340	48	4	335	23	7	343	23	4
5	384	21	5	379	8	12	389	10	5
6	409	4	7	409	4	7		0	
7	424	7	7	430	3	4	419	4	13
8	419	5	8	425	2	5	415	3	13
9	432	5	18	450	3	7	406	2	42
10	422	3	5	424	2	8	418	1	
11	417	2	5		0		417	2	5
12	412	1			0		412	1	
13	429	1		429	1			0	
14	456	3	8	462	2	10	445	1	
15	430	1		430	1			0	
16		0			0			0	
All	326	157	7	354	65	8	350	64	7

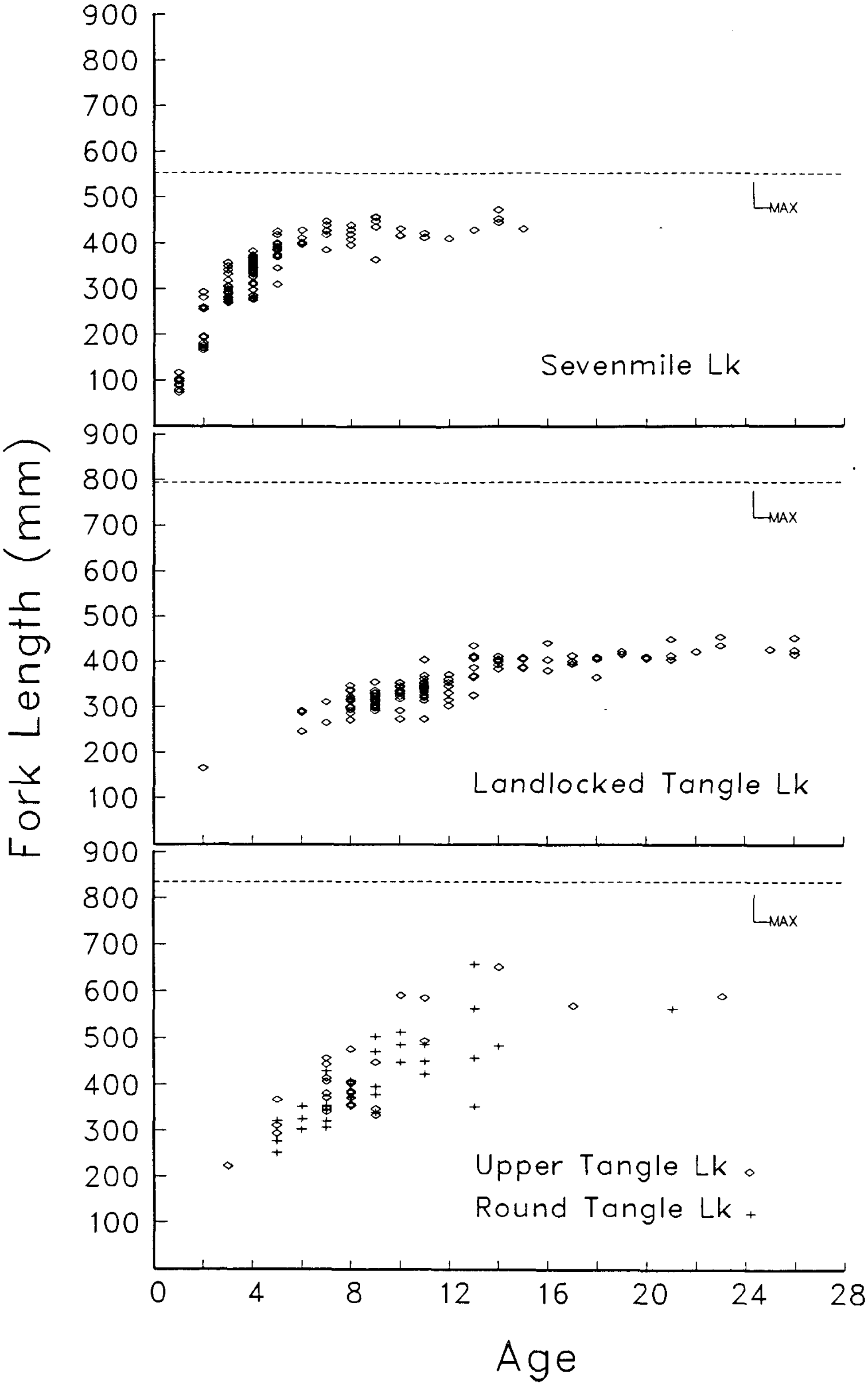


Figure 5. Length and age of lake trout from Sevenmile Lake, Landlocked Tangle Lake, Upper Tangle Lake, and Round Tangle Lake. L_{MAX} indicates the length of the largest lake trout observed from each population.

Table 6. Estimated length (mm FL) at age (from otoliths) of lake trout from Landlocked Tangle Lake, 1987-1991.

	All Lake Trout			Female Lake Trout			Male Lake Trout		
Age	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE
0		0			0			0	
1		0			0			0	
2	163	1			0		163	1	
3		0			0			0	
4		0			0			0	
5		0			0			0	
6	274	3	15		0		268	2	23
7	287	2	23		0		264	1	
8	310	17	5	309	8	8	308	5	11
9	318	21	3	319	15	4	319	4	5
10	327	13	6	325	4	13	335	8	4
11	340	20	6	333	9	9	345	10	8
12	342	8	9	347	4	12	336	4	13
13	380	9	13	360	4	13	414	4	6
14	398	6	4	399	3	5	396	3	7
15	395	4	6	396	2	10	393	2	10
16	406	3	17	402	1		408	2	30
17	403	4	5	404	3	6	398	1	
18	391	3	14	403	1		385	2	22
19	416	2	3	416	2	3		0	
20	406	3	1	406	3	1		0	
21	420	3	14	429	2	19	402	1	
22	419	1			0		419	1	
23	442	2	10	452	1			0	
24		0			0			0	
25	424	1		424	1			0	
26	428	3	11	422	1		413	1	
All	349	129	4	353	64	6	348	52	7

Table 7. Estimated length (mm FL) at age (from otoliths) of lake trout from Upper Tangle Lake, 1987-1991.

Age	All Lake Trout			Female Lake Trout			Male Lake Trout		
	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE
0		0			0			0	
1		0			0			0	
2		0			0			0	
3	220	1			0		220	1	
4		0			0			0	
5	338	4	22	353	3	23	292	1	
6	268	2	14	282	1			0	
7	359	15	13	354	8	12	351	6	24
8	391	9	12	373	4	12	405	5	18
9	373	3	36	445	1		338	2	7
10	588	1		588	1			0	
11	537	2	46	583	1			0	
12		0			0			0	
13		0			0			0	
14	650	1		650	1			0	
15		0			0			0	
16		0			0			0	
17	566	1		566	1			0	
18		0			0			0	
19		0			0			0	
20		0			0			0	
21		0			0			0	
22		0			0			0	
23	587	1			0		587	1	
All	390	40	15	405	21	23	369	16	21

Table 8. Estimated length (mm FL) at age (from otoliths) of lake trout from Round Tangle Lake, 1987-1991.

	All Lake Trout			Female Lake Trout			Male Lake Trout		
Age	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE
0		0			0			0	
1		0			0			0	
2		0			0			0	
3		0			0			0	
4		0			0			0	
5	281	3	20		0			0	
6	324	3	14		0		311	2	11
7	349	6	17		0		426	1	
8	389	2	18		0		371	1	
9	415	5	30	500	1			0	
10	479	3	19	510	1			0	
11	450	3	18		0			0	
12		0			0			0	
13	505	4	66	350	1		655	1	
14	480	1			0			0	
15		0			0			0	
16		0			0			0	
17		0			0			0	
18		0			0			0	
19		0			0			0	
20		0			0			0	
21	560	1			0			0	
22		0			0			0	
23		0			0			0	
All	407	31	17	453	3	52	415	5	64

(Burr 1991b). In the connected Tangle Lakes, growth does not decline with maturation (LM_{50} = 400 mm, AM_{50} = 8 years).

In Sevenmile Lake, the maximum observed fork length of 550 mm is consistent with the growth pattern indicated by length at age estimates (Figure 5). The growth of some fish captured in Landlocked Tangle Lake did not fall within the pattern shown in Figure 5. A small portion (4%) of the lake trout were larger (500 to 800 mm) but not killed and no age data are available (Burr 1988). The growth of these larger fish was likely similar to that observed for lake trout from the connected Tangle Lakes. In Upper Tangle Lake, the largest fish captured was 835 mm FL (Burr 1989) which is consistent with the growth pattern from the length at age data (Figure 5). About 5% of the lake trout captured were larger than the length range for which age data were obtained.

The small size and the rapid initial growth of lake trout in Sevenmile Lake is consistent with other populations of lake trout inhabiting small lakes. Small oligotrophic lakes are characterized by low fish species diversity. In these lakes, lake trout diet is typically composed of benthic invertebrates and zooplankton. Piscivory is necessary for attainment of large body size in lake trout (Martin and Olver 1980, Carl et al. 1990). In the connected Tangle Lakes, lake trout grow to larger size. Relatively abundant populations of round whitefish are present along with Arctic grayling, and longnosed suckers. Although round whitefish are present in Landlocked Tangle Lake, most lake trout are planktivorous/benthivorous and few lake trout attain large size.

SPAWNING SITES - SEVENMILE AND THE TANGLE LAKES

Methods

Between August 20 and 28, physical surveys were conducted of the shore lines of Sevenmile Lake, Landlocked Tangle Lake and the connected Tangle Lakes (Upper, Round, Shallow, and Lower; Figure 1) to identify potential spawning sites. Certain physical characteristics are common to most lake trout spawning sites, particularly in lakes less than 2,000 ha. Criteria established by MacLean et al. (1990) which consider these physical features were used to identify and map sites which were likely to be used by lake trout for spawning. Nighttime surveys were then conducted during the probable spawning season (10 September - 3 October) to determine which, if any, of the potential areas were active spawning sites. Visual surveys of the previously identified areas were conducted using halogen spotlights to locate spawning lake trout. When lake trout were observed, small mesh gill nets (and where possible, beach seines) were used to capture lake trout. All lake trout captured were measured and marked with Floy anchor tags and were given a left pelvic fin clip. Sex and spawning condition were recorded. The location of these sites was recorded on maps. After the potential spawning areas were surveyed, sites which were found to be active were further sampled to obtain additional information on the timing of the spawning season and the size of the spawning fish.

Results and Discussion

Active spawning sites were found in Sevenmile Lake, Landlocked Tangle Lake, Round Tangle Lake and Lower Tangle Lake. No spawning lake trout were observed or captured in Upper Tangle Lake or in Shallow Tangle Lake during the sampling period.

Visual surveys in the connected Tangle Lakes were generally ineffective. Water clarity in these lakes was poor, largely due to plankton. Only one active spawning site was visually located at Round Tangle Lake where lake trout were spawning in very shallow water (< 1.5 m). Visibility was better at Landlocked Tangle Lake where numerous lake trout were sighted. However no large groups (10 or more) of lake trout were observed. Similarly, no large groups or clusters of lake trout were seen in Sevenmile Lake.

Because visual surveys were largely ineffective at locating spawning fish, small mesh gill nets were used for 15 minutes or less to determine the presence or absence of spawning lake trout at potential spawning sites. Relatively abundant populations of round whitefish and longnose suckers precluded the effective use of these gill nets in Upper Tangle, Round Tangle and Shallow Tangle lakes. Spawning concentrations of lake trout were located in Lower Tangle Lake and in Sevenmile Lake using the short duration "blind" gill net sets.

The number of mature lake trout sampled in the Tangle Lakes during the spawning season was low. Sixty-two mature lake trout were captured in all of the Tangle Lakes combined: 22 in Landlocked Tangle, 22 in Round Tangle, and 18 in Lower Tangle Lake (Figure 6). Of the fish for which sex could be positively determined, 38% were females and 61% were males. In Sevenmile Lake a total of 80 spawning lake trout were sampled. Thirty-three percent were females and 67% were males.

Fork lengths of spawning lake trout in the connected Tangle Lakes appeared to increase with distance from the boat launch (access point) although sample size was very limited (Figure 6). Mean length of spawning lake trout in Round Tangle Lake was 494 mm FL (SE = 13) compared with 563 mm (SE = 20) in the more remote Lower Tangle Lake. The average length of mature lake trout in Landlocked Tangle Lake, which is not connected to the other lakes in the system, was less (406 mm FL, SE = 10). In much smaller Sevenmile Lake, the mean length of spawning lake trout was 427 mm FL (SE = 3).

Lake trout were spawning in the Tangle Lakes between mid-September and the first week of October. In Landlocked Tangle Lake, all sized lake trout captured on 13 September were not yet ripe. By 30 September, all mature sized females were spent. Water temperature in Landlocked Tangle Lake decreased from 8.9^{o} C to 2.8^{o} C during this period. In Round Tangle Lake, mature sized lake trout were not yet ripe on 14 September. Lake trout which were actively spawning were not captured until 1 October. On that date in Round Tangle Lake, all females were spent or partially spent. Water temperature was 2.8^{o} C. In Lower Tangle Lake, prespawning, ripe and partially spent lake trout were captured on 18 September. Water temperature was 3.9^{o} C. In Sevenmile Lake, actively spawning lake trout were captured on September 16.

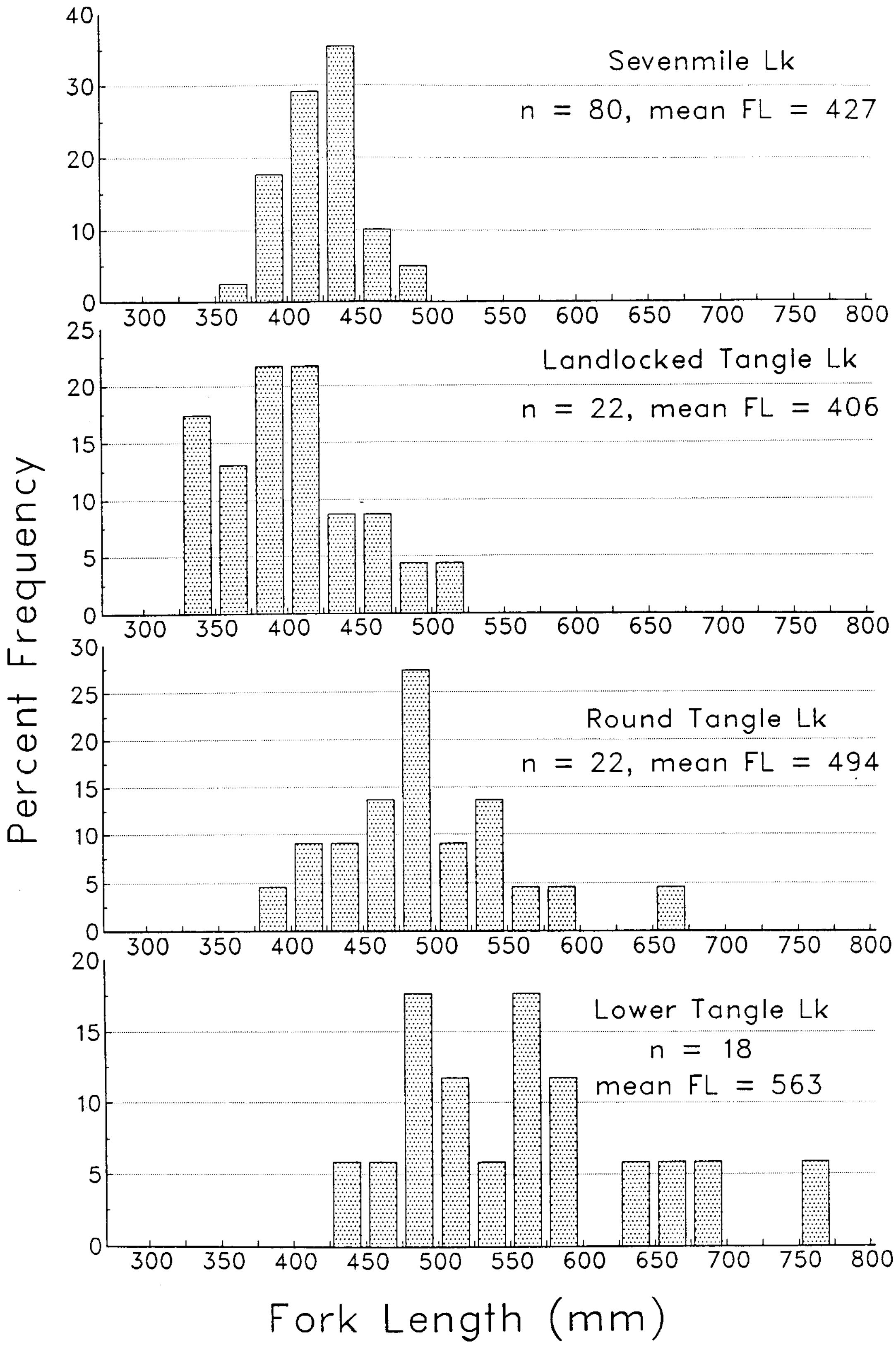


Figure 6. Length distribution of lake trout sampled during the spawning season from Sevenmile Lake, Landlocked Tangle Lake, Round Tangle Lake and Lower Tangle Lake.

On that date, water temperature was 4.4^{o} C. The relatively abundant populations of round whitefish in three of the connected Tangle Lakes and the longnose suckers in Upper Tangle Lake made use of "blind" gill nets impractical. Low water clarity prevented visual surveys except in very shallow water. These conditions prevented effective sampling in Upper Tangle, Round Tangle, and Shallow Tangle Lakes. A single group of approximately 20 spawning lake trout was observed in shallow water in Round Tangle Lake. This suggests that if other substantial spawning groups had been present, visual surveys should have been able to detect them. However, in Lower Tangle Lake, spawning lake trout were captured with gill nets set at potential spawning sties although no lake trout were seen during visual surveys. The lake trout were caught in depths varying from 3 to 10 m, below the depth of light penetration in this lake. In Sevenmile Lake, although small groups of lake trout were observed, the large groups of spawning lake trout (20 to 50) were not seen during visual surveys but were "discovered" through the use of systematic gill net sets along the shore over appropriate substrate. These fish were captured in only 2 to 3 m of water. Because habitat which appears to be suitable for spawning exists in all of the Tangle Lakes, it seems likely that some lake trout spawn in each of the lakes. Lake trout may be spawning in water too deep for detection via visual survey.

It is unknown whether the low number of lake trout captured in the Tangle Lakes reflects very low abundance of spawning lake trout or is simply the result of ineffective sampling under the described conditions. Although not conclusive, the low number of spawners found at the active sites which were identified suggests low abundance. The largest group of lake trout encountered in the Tangle lakes was 21 fish. This is in contrast to Sevenmile Lake where 47 lake trout were caught in a single gill net set.

ANGLER HARVEST SURVEY - TANGLE LAKES

Methods

Annual lake trout harvest is estimated with a statewide mail harvest survey. The estimated harvest of lake trout from the Tangle Lakes during 1989 was 478 fish (Mills 1990). This estimate was based on the response of 20 households reporting the harvest of a total of 44 lake trout.

To determine the location of harvest of lake trout in the Tangle Lakes during the 1989 season, a mail survey was used. Questionnaires were sent to the 20 households which responded to the statewide harvest survey (Mills 1990) as having caught and kept lake trout from the Tangle Lakes. The questionnaire asked each recipient to identify the location of catch for the lake trout that they reported harvesting. Appendix B contains a copy of the questionnaire and letter that accompanied it.

The estimated harvest reported by Mills (1990) was adjusted by the proportion of lake trout reportedly taken from the Tangle Lakes by respondents to my survey as follows (Goodman 1960):

$$\hat{H} = \hat{p}\,\hat{H}_M\text{; and,} \tag{12}$$

$$\hat{V}[\hat{H}] = \hat{p}^2\,\hat{V}[\hat{H}_M] + \hat{V}[\hat{p}]\,\hat{H}_M^2 - \hat{V}[\hat{p}]\,\hat{V}[\hat{H}_M]; \tag{13}$$

where:

$\hat{H}$ = adjusted estimated harvest of lake trout from the Tangle Lakes;

$\hat{H}_M$ = estimate of harvest of lake trout from Mills (1990); and,

$\hat{p}$ = estimate of the proportion of lake trout reportedly harvested from the Tangle Lakes.

Results

Sixteen of the 20 households (80%) which were sent a survey questionnaire responded. Two of the questionnaires were not deliverable and two were never answered despite repeated attempts to encourage return of the survey. The sixteen households which returned the questionnaire accounted for 35 (79.5%) of the total of 44 lake trout reported to Mills (1990).

An estimated 68.6% of the lake trout which were reported harvested from the Tangle Lakes were subsequently reported to have been actually harvested within this lake system (Table 9). The remaining 31.4% of these fish were inappropriately reported to Mills (1990) as lake trout harvested from the Tangle Lakes. Two lake trout (5.7%) were harvested from nearby Glacier Lake. Two lake trout (5.7%) were caught but not kept. A total of seven fish (20%) were reported to me to actually be species other than lake trout: five Arctic grayling from Upper Tangle Lake and two rainbow trout from Koole Lake.

Lake trout harvested from the Tangle Lakes in 1989 were most often caught in the lakes closest to the road and campgrounds. Campgrounds and direct road access are provided for Upper Tangle Lake and Round Tangle Lake. The remaining lakes in the system are more remote (Appendix B). Fifty-seven percent of the reported harvest came from these two lakes (Table 9). No lake trout harvest was reported from the lakes farthest from the road. In addition to harvest, most of the fishing effort directed at catching lake trout by respondents to the survey was confined to the two most accessible lakes. Nine of the eleven households (82%) fished in Upper Tangle and Round Tangle Lakes.

Mills (1990) reported an estimated harvest of 478 lake trout (SE = 128) from the Tangle Lakes in 1989. Considering the results of the questionnaire reported here, this estimate is too high. When the estimated harvest is reduced by the proportion of lake trout taken from this lake system as reported to me, the estimated harvest decreases to 328 lake trout (SE = 95). However, the two estimates of harvest of lake trout are not significantly different (t test, P = 0.17).

Table 9. Number of households responding to survey questionnaire and the location of catch of lake trout reported from the Tangle Lakes in 1989.

Location/Response	Number of Questionnaires	Number of Lake Trout	Percent of Lake Trout
Landlocked Tangle Lake	1	2	5.7
Upper Tangle Lake	5	11	31.4
Round Tangle Lake	5	9	25.7
Shallow Tangle Lake	1	2	5.7
Long Tangle Lake	0	0	0.0
Lower Tangle Lake	0	0	0.0
Total Tangle Lakes	11[a]	24	68.6
Rock Creek	0	0	0.0
Landmark Gap Lake	0	0	0.0
Glacier Lake	1	2	5.7
Other Lakes	0	0	0.0
Caught but not kept	2	2	5.7
Other Species[b]	2	7	20.0
Total Response	16	35	100.0

[a] One respondent caught fish in both Round and Upper Tangle Lakes.
[b] Five Arctic grayling - Upper Tangle Lake, two rainbow trout - Koole Lake.

Discussion

The level of harvest during 1989 from the Tangle Lakes as reported by Mills (1990) was greater than the 0.5 kg/ha/year harvest guideline recommended by Healey (1978). The 478 lake trout reported correspond to approximately 500 kg (Burr *In prep*) or 0.6 kg/ha. This estimated harvest was cause for concern especially in light of the very restrictive regulations in effect for this lake system. The adjusted estimated harvest of 328 lake trout corresponds to approximately 340 kg or 0.4 kg/ha and is within the annual harvest guideline. Estimated harvests from the Tangle Lakes for other years since the adoption of the current regulations were 127 lake trout in 1988 and 236 lake trout in 1990 (Mills 1989, 1991). Until 1991, estimates of error associated with the harvest estimates were not available. The variability seen in these estimates argues against relying too heavily on a single annual estimate. For lake trout populations where harvest is estimated from relatively few respondents, results from the statewide harvest survey are most appropriately used for trend information.

GENERAL DISCUSSION

The abundance of mature lake trout in Sevenmile Lake appears to be approximately 500 fish. This corresponds to about 15 kg/ha. Dense populations of small lake trout are typical in small lakes which do not contain populations of forage fish (Burr *In prep*). In most lake trout populations studied in Alaska, density is inversely related to lake size. The lake trout population in Landlocked Tangle Lake (1,645 mature fish, 4.3 kg/ha; Burr 1988) fits within this generalization. The population of lake trout in Upper Tangle Lake (96 mature fish, 1.2 kg/ha; Burr 1989) does not. The low abundance of lake trout in Upper Tangle Lake is believed to be due to suboptimal habitat and heavy exploitation by the recreational fishery.

The sex ratio of approximately three males to each female observed from the spawning samples collected from the Tangle Lakes and Sevenmile Lake may indicate that females do not spawn consecutively in these populations. Recapture rates for female lake trout after four years of sampling in Paxson Lake suggested that females do not spawn every year once maturity is attained (Burr 1991a). However, an uneven sex ratio where males are proportionately more abundant is typical of spawning lake trout (Martin and Olver 1980) and does not necessarily indicate nonconsecutive spawning. Time series data over numerous spawning seasons will be required to determine the frequency of spawning for individuals from these populations.

Exploitation is likely a factor in the growth rates seen in Sevenmile Lake and in the Tangles system. Growth is relatively rapid in Sevenmile Lake and in Round and Upper Tangle lakes. Growth is slower in Landlocked Tangle Lake. Direct access is provided for Sevenmile Lake and for Round and Upper Tangle lakes. Landlocked Tangle is more remote. Population density of lake trout is low in Upper Tangle Lake as compared to nearby Landlocked Tangle Lake. Estimates of abundance of lake trout for the remainder of the Tangle Lakes are not available. Samples of adult lake trout captured during spawning season in the connected Tangle Lakes (Landlocked Tangle excluded) suggests that mean size increases with distance from access points. Age data from lake trout killed in the course of sampling (Figure 5) indicate that few older fish are present in the more accessible lakes. Data presented in this report show that most effort for and harvest of lake trout come from the more accessible Upper and Round Tangle lakes. In summary, in the more heavily fished Round and Upper Tangle lakes, growth is faster while lake trout are younger and smaller. The more rapid growth of lake trout in the more accessible Tangle Lakes may a compensatory response to low population density of lake trout in the presence of abundant prey.

The restrictive bag and possession limits for lake trout in place for the Tangle Lakes appears to be effective at maintaining harvest below the guideline yield level of 0.5 kg/ha. However, it is desirable to prevent further declines in the size, age, and abundance of lake trout in these populations. Because of the high level of harvest of lake trout from these lakes prior to 1987 and because of the increasing effort directed at lake trout and other species in this system, liberalization of these regulations is not recommended at this time.

From a fishery management perspective, it is significant that a large portion of the harvest (57%) and effort (82%) were at the two most accessible lakes. Numerous studies have reported that effort is the single most important factor determining harvest of lake trout (Lester et al. 1991, Goddard et al. 1987, and Evans et al. 1991) Strictly from a stock conservation perspective, these results question the wisdom of the current policy of providing better and easier access to lakes containing wild lake trout stocks (e.g. Fielding Lake). Better access will undoubtedly result in more effort directed at these populations and in increased harvest. Because of the inherent characteristics of this species, these stocks are unable to provide a large annual surplus for harvest. It may be necessary to offset increased access with increasingly restrictive harvest regulations.

ACKNOWLEDGEMENTS

I would like to thank Jared Baker, Pat Houghton, and Larry King who assisted with the field work associated with this study. Thanks also to Patricia Hansen for assistance with statistical procedures, data analysis and scientific editing. Appreciation is extended to Margaret Merritt and John H. Clark for editorial comments and support in all aspects of this project. I also thank the U. S. Fish and Wildlife Service for funding support through the Federal Aid in Fish Restoration Act, (16 U.S.C. 777-777K) under Project F-10-7, Study R, Job No. 3-3(a).

LITERATURE CITED

Buckland, S.T. 1980. A modified analysis of the Jolly-Seber capture-recapture model. Biometrics 36:419-435.

Buckland, S.T. 1982. A mark-recapture survival analysis. Journal of Animal Ecology 51:833-847.

Burr, J. M. 1988. Stock assessment and biological characteristics of lake trout populations in Interior Alaska, 1987. Alaska Department of Fish and Game, Fisheries Data Series No. 66, Juneau. 53 pp.

_____. 1989. Stock assessment and biological characteristics of lake trout populations in Interior Alaska, 1988. Alaska Department of Fish and Game, Fisheries Data Series No. 99, Juneau. 57 pp.

_____. 1990. Stock assessment and biological characteristics of lake trout populations in Interior Alaska, 1989. Alaska Department of Fish and Game, Fisheries Data Series No. 90-33, Juneau. 50 pp.

_____. 1991a. Lake trout population studies in interior Alaska, 1990, including abundance estimates of lake trout in Glacier, Sevenmile, and Paxson lakes during 1989. Alaska Department of Fish and Game, Fisheries Data Series No. 91-7, Juneau. 50 pp.

_____. 1991b. Length limit regulations as applied to Alaskan lake trout fisheries, a synthesis of available data with recommendations. Alaska Department of Fish and Game, Fisheries Manuscript Series No. 91-5, Juneau. 23 pp.

_____. *In prep*. A summary of abundance and density estimates for interior Alaska's lake trout populations and an examination of trends in yield. Alaska Department of Fish and Game, Fisheries Manuscript Series, Anchorage.

Carl, L., M-F. Bernier, W. Christie, L. Decon, P. Hulsman, D. Loftus, D. Maraldo, T. Marshall, and P. Ryan. 1990. Fish community and environmental effects on lake trout. Lake trout Synthesis, Ontario Ministry Natural Resources, Toronto. 47 p.

Chapman, D. G. 1951. Some properties of the hypergeometric distribution with applications to zoological censuses. University of California Publications in Statistics 1, 131-60.

Conover, W. J. 1980. Practical nonparametric statistics. John Wiley and Sons, New York. 493 pp.

Efron, B. 1982. The jackknife, the bootstrap, and other resampling plans. Society of Industrial and Applied Mathematics, Philadelphia. 92pp.

Evans, D. O., J. M. Casselman, and C. C. Willox. 1991. Effects of exploitation, loss of nursery habitat, and stocking on the dynamics and productivity of lake trout populations in Ontario lakes. Lake trout Synthesis, Ontario Ministry Natural Resources, Toronto. 193 pp.

Gabelhouse, D. W. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management. 4:273-285.

Goddard, C. I., D. H. Loftus, J. A. MacLean, C. H. Olver, and B. J. Shuter. 1987. Evaluation of the effects of fish community structure on observed yields of lake trout (*Salvelinus namaycush*). Canadian Journal of Fisheries and Aquatic Sciences. 44(Suppl. 2): 239-248.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association. 66:708-713.

Healey, M. C. 1978. Dynamics of exploited lake trout populations and implications for management. Journal Wildlife Management. 42:307-328.

Lester, N. P., M. M. Petzold, W. I. Dunlop, B. P. Monroe, S. D. Orsatti, T. Schaner, and D. R. Wood. 1991. Sampling Ontario lakes: issues and standards. Lake trout Synthesis, Ontario Ministry Natural Resources, Toronto. 117 p.

MacLean, N. G., J. M. Gunn, F. J. Hicks, P. E. Ihssen, M. Malhiot, T. E. Mosindy, and W. Wilson. 1990. Environmental and genetic factors affecting the physiology and ecology of lake trout. Lake trout Synthesis, Ontario Ministry Natural Resources, Toronto. 84 p.

Martin, N. V. and C. H. Olver. 1980. The lake charr, *Salvelinus namaycush*. Pages 205-277 *in* E. K. Balon, ed. Charrs: Salmonid Fishes of the Genus Salvelinus. D. W. Junk Publishers, The Hague, Netherlands.

Mills, M. J. 1989. Alaska statewide sport fisheries harvest report, 1988. Alaska Department of Fish and Game, Fisheries Data Series No. 122, Juneau 142 pp.

_____. 1990. Harvest and participation in Alaska sport fisheries during 1989. Alaska Department of Fish and Game, Fisheries Data Series No. 90-44, Juneau 152 pp.

_____. 1991. Harvest, catch and participation in Alaska sport fisheries during 1990. Alaska Department of Fish and Game, Fisheries Data Series No. 91-58, Juneau. 183 pp.

Robson, D. S. and W. A. Flick. 1965. A non-parametric statistical method for culling recruits from a mark-recapture experiment. Biometrics 21: 936-947.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, 2nd ed. Charles Griffin & Company, Ltd. London. 624 pp.

APPENDIX A

Appendix A1. Length frequencies (listed by gear type) of all lake trout captured and marked during 1990 in Sevenmile Lake.

	Captured								Released with Tags in 1990							
Fork[a] Length (mm)	Gill Nets		Fyke Nets		Hoop Nets		All Gear		Gill Nets		Fyke Nets		Hoop Nets		All Gear	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
50	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	2	11	0	0	2	1	0	0	0	0	0	0	0	0
125	0	0	12	63	0	0	12	4	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	3	16	0	0	3	1	0	0	0	0	0	0	0	0
200	1	0	2	11	0	0	3	1	0	0	0	0	0	0	0	0
225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	5	2	0	0	0	0	5	2	5	2	0	0	0	0	5	2
275	19	7	0	0	0	0	19	6	17	7	0	0	0	0	17	7
300	14	5	0	0	0	0	14	5	9	4	0	0	0	0	9	4
325	4	1	0	0	0	0	4	1	3	1	0	0	0	0	3	1
350	25	9	0	0	0	0	25	8	18	7	0	0	0	0	18	7
375	21	8	0	0	0	0	21	7	16	7	0	0	0	0	16	6
400	36	13	0	0	0	0	36	12	32	13	0	0	0	0	32	13
425	58	21	0	0	1	50	59	20	57	23	0	0	1	50	58	23
450	58	21	0	0	1	50	59	20	55	22	0	0	1	50	56	23
475	28	10	0	0	0	0	28	9	28	11	0	0	0	0	28	11
500	2	1	0	0	0	0	2	1	2	1	0	0	0	0	2	1
525	2	1	0	0	0	0	2	1	2	1	0	0	0	0	2	1
550	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	274		19		2		295		245		0		2		247	
Mean	388		124		424		371		395		nd		424		394	
> 249 Total	269		0		2		271		240		0		2		243	
Mean	391		nd		424		391		396		nd		424		396	

[a] Upper limit length category.

Appendix A2. Length frequencies (listed by gear type) of all lake trout captured in 1991 in Sevenmile Lake.

Fork Length (mm)[a]	Captured								Recaptured from 1990								Released with tags in 1991							
	Gill Nets		Fyke Nets		Hoop Nets		All Gear		Gill Nets		Fyke Nets		Hoop Nets		All Gear		Gill Nets		Fyke Nets		Hoop Nets		All Gear	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
50	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0	0	0	0.0	0	0.0	0	0	0	0.0	0	0.0
75	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0	0	0	0.0	0	0.0	0	0	0	0.0	0	0.0
100	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0	0	0	0.0	0	0.0	0	0	0	0.0	0	0.0
125	0	0.0	1	10.0	0	0.0	1	0.3	0	0.0	0	0	0	0	0	0.0	0	0.0	0	0	0	0.0	0	0.0
150	0	0.0	1	10.0	0	0.0	1	0.3	0	0.0	0	0	0	0	0	0.0	0	0.0	0	0	0	0.0	0	0.0
175	0	0.0	1	10.0	0	0.0	1	0.3	0	0.0	0	0	0	0	0	0.0	0	0.0	0	0	0	0.0	0	0.0
200	0	0.0	5	50.0	0	0.0	5	1.4	0	0.0	0	0	0	0	0	0.0	0	0.0	0	0	0	0.0	0	0.0
225	2	0.6	1	10.0	0	0.0	3	0.8	0	0.0	0	0	0	0	0	0.0	0	0.0	0	0	0	0.0	0	0.0
250	4	1.1	0	0.0	0	0.0	4	1.1	0	0.0	0	0	0	0	0	0.0	3	1.0	0	0	0	0.0	3	1.0
275	17	4.8	0	0.0	0	0.0	17	4.7	0	0.0	0	0	0	0	0	0.0	13	4.3	0	0	0	0.0	13	4.2
300	34	9.7	0	0.0	0	0.0	34	9.3	0	0.0	0	0	0	0	0	0.0	22	7.3	0	0	0	0.0	22	7.2
325	16	4.5	0	0.0	0	0.0	16	4.4	0	0.0	0	0	0	0	0	0.0	11	3.6	0	0	0	0.0	11	3.6
350	16	4.5	0	0.0	0	0.0	16	4.4	0	0.0	0	0	0	0	0	0.0	12	4.0	0	0	0	0.0	12	3.9
375	34	9.7	0	0.0	0	0.0	34	9.3	1	3.3	0	0	0	0	1	3.2	22	7.3	0	0	0	0.0	22	7.2
400	42	11.9	0	0.0	0	0.0	42	11.5	4	13.3	0	0	0	0	4	12.9	38	12.5	0	0	0	0.0	38	12.4
425	61	17.3	1	10.0	0	0.0	62	17.0	8	26.7	1	100	0	0	9	29.0	60	19.8	1	100	0	0.0	61	19.9
450	77	21.9	0	0.0	1	50.0	78	21.4	14	46.7	0	0	0	0	14	45.2	74	24.4	0	0	1	50.0	75	24.5
475	36	10.2	0	0.0	1	50.0	37	10.2	3	10.0	0	0	0	0	3	9.7	35	11.6	0	0	1	50.0	36	11.8
500	11	3.1	0	0.0	0	0.0	11	3.0	0	0.0	0	0	0	0	0	0.0	11	3.6	0	0	0	0.0	11	3.6
525	1	0.3	0	0.0	0	0.0	1	0.3	0	0.0	0	0	0	0	0	0.0	1	0.3	0	0	0	0.0	1	0.3
550	1	0.3	0	0.0	0	0.0	1	0.3	0	0.0	0	0	0	0	0	0.0	1	0.3	0	0	0	0.0	1	0.3
Total	356		10		2		368		31		1		0		32		307		1		2		310	
Mean	388		198		459		384		426		418				432		398		418		459		399	
> 249																								
Total	352		1		2		355		31		1		0		32		306		1		2		309	
Mean	391		418		459		391		427		418				432		399		418		459		399	

[a] Upper limit length category.

Appendix A3. Number of lake trout marked, recaptured with tags and tag loss in Sevenmile Lake from 1987 through 1991.

Number of Lake Trout	Year				
	1987	1988	1989	1990	1991
Marked	166	156	146	247	310
Recaptured (tagged)[a]		25	17	18	32
Recaptured (tag loss)[b]		6	5	12	41
Recaptured (total)		31	22	30	73
Tag Loss %		19.35	unknown	unknown	unknown

[a] From preceding year.
[b] From one of the preceding years.

To adjust for tag loss in the estimate of abundance for the 1990-1991 data, the number of recaptures (32) was increased by 19.35% to 40. However, it was necessary to stratify the data for estimating population abundance due to growth recruitment. The estimated total number of recaptures (40) was reduced by the proportion of recaptures which were smaller than the upper extant of growth recruitment:

$$R_l = R_t - (p_s * R_t)$$

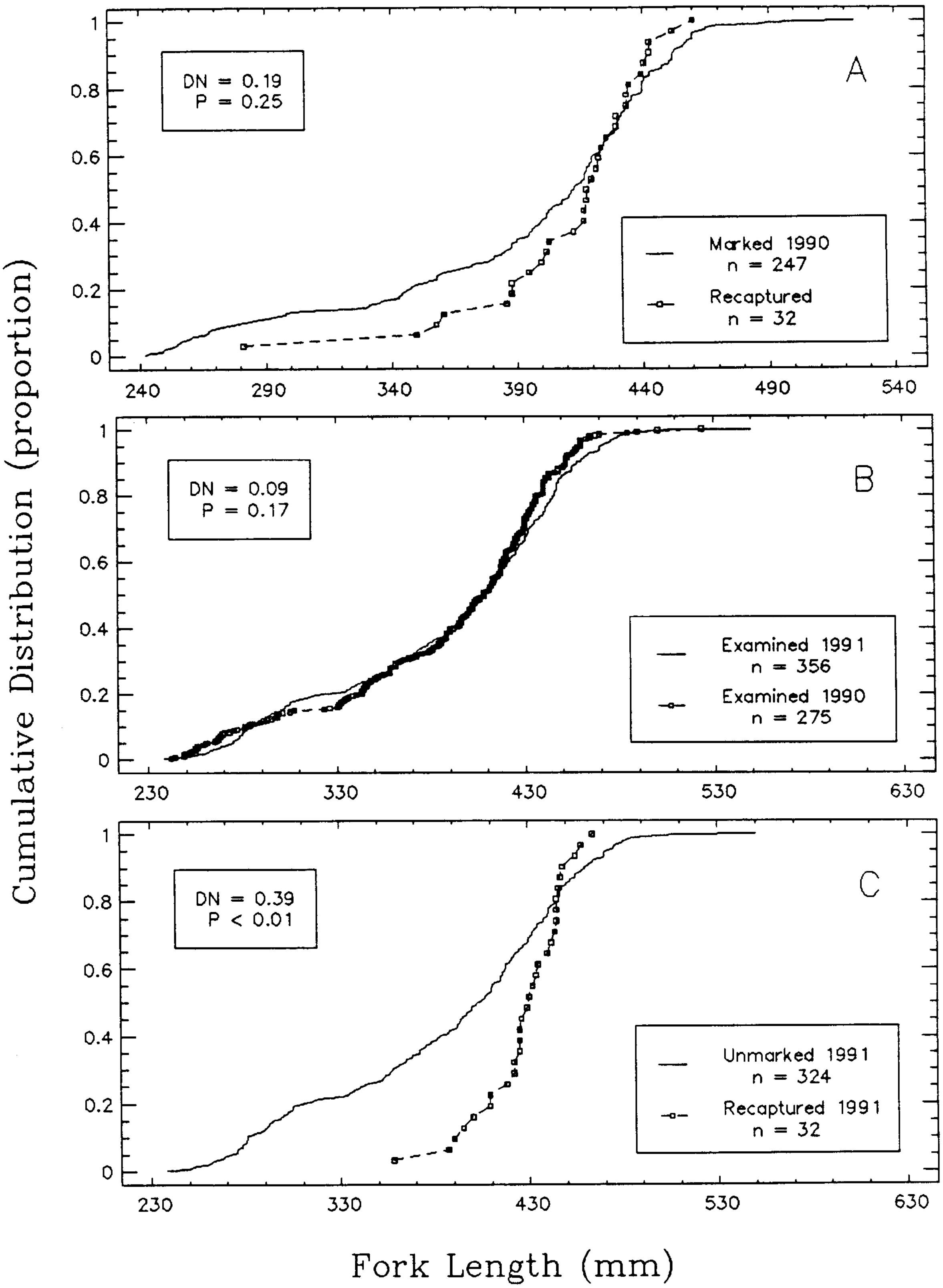
where:

R_l = Number of recaptures in the large strata (FL > 389 mm);
R_t = Total number of recaptures; and,
p_s = Proportion of recaptures smaller than the upper extant of growth recruitment (FL <390 mm).

$$R_l = 40 - (2/32 * 40)$$

Hence, the number of recaptures used to estimate abundance in the larger strata (FL > 389 mm) was 37.

Appendix A4. Results of KS two sample tests comparing lengths of lake trout caught during sampling in 1990 and 1991. Panel A compares all lake trout marked and released in 1990 and recaptured in 1991. Panel B compares all lake trout captured in 1990 and in 1991. Panel C compared all lake trout captured without tags from 1990 in 1991 and those captured with 1990 tags in 1991.



Appendix A5. Length frequencies of all lake trout captured, marked, and recaptured in Sevenmile Lake in 1991.

Fork Length (mm)[a]	August 1991				September 1991			
	Captured		Marked		Captured		Recaptured	
	n	%	n	%	n	%	n	%
50	0	0.0	0	0.0	0	0.0	0	0.0
75	0	0.0	0	0.0	0	0.0	0	0.0
100	0	0.0	0	0.0	0	0.0	0	0.0
125	0	0.0	0	0.0	0	0.0	0	0.0
150	0	0.0	0	0.0	0	0.0	0	0.0
175	0	0.0	0	0.0	0	0.0	0	0.0
200	0	0.0	0	0.0	0	0.0	0	0.0
225	0	0.0	1	0.4	0	0.0	0	0.0
250	3	1.1	1	0.4	3	3.1	0	0.0
275	16	5.7	1	0.4	12	12.2	0	0.0
300	33	11.7	1	0.4	21	21.4	0	0.0
325	10	3.5	6	2.5	6	6.1	0	0.0
350	15	5.3	1	0.4	11	11.2	0	0.0
375	29	10.3	7	2.9	18	18.4	2	8.0
400	30	10.6	17	7.0	28	28.6	5	20.0
425	46	16.3	23	9.5	45	45.9	7	28.0
450	60	21.3	28	11.6	58	59.2	8	32.0
475	31	11.0	8	3.3	31	31.6	3	12.0
500	7	2.5	4	1.7	7	7.1	0	0.0
525	1	0.4	0	0.0	1	1.0	0	0.0
550	1	0.4	0	0.0	1	1.0	0	0.0
> 249								
Total	282		242		101		26	
Mean	387		397		407		422	
> 369								
Total	185		177		82		26	
Mean	429		430		425		422	

[a] Upper limit length category.

Appendix A6. Length (mm FL) of lake trout from Sevenmile Lake at time of marking and at recapture with growth between sample periods.

Period	Length at Marking	Length at Recapture	Annual Growth	Period	Length at Marking	Length at Recapture	Annual Growth	Period	Length at Marking	Length at Recapture	Annual Growth
1987-88	200	274	74	1987-88	395	395	0	1990-91	422	430	8
1987-88	231	325	94	1989-90	395	402	7	1989-90	422	433	11
1987-88	234	345	111	1987-88	395	405	10	1990-91	423	440	17
1987-88	240	340	100	1990-91	395	409	14	1990-91	424	422	2
1987-88	244	332	88	1987-88	397	415	18	1990-91	426	435	9
1987-88	245	349	104	1989-90	398	435	37	1990-91	430	442	12
1987-88	246	353	107	1988-89	399	401	2	1990-91	430	446	16
1987-88	247	351	104	1988-89	400	412	12	1988-89	431	436	5
1987-88	253	355	102	1990-91	400	418	18	1988-89	433	441	8
1989-90	280	332	52	1989-90	402	402	0	1989-90	434	440	6
1990-91	281	358	77	1990-91	402	409	7	1988-89	434	443	9
1989-90	295	348	53	1990-91	403	425	22	1990-91	434	444	10
1987-88	317	371	54	1988-89	410	434	24	1990-91	434	445	11
1987-88	320	394	74	1988-89	412	420	8	1987-88	435	440	5
1988-89	347	382	35	1990-91	413	422	9	1990-91	435	458	23
1987-88	347	391	44	1989-90	414	416	2	1990-91	440	445	5
1988-89	352	390	38	1988-89	416	430	14	1990-91	441	445	4
1988-89	357	386	29	1990-91	417	425	8	1990-91	443	447	4
1990-91	358	387	29	1990-91	417	426	9	1990-91	443	448	5
1988-89	361	391	30	1987-88	418	420	2	1989-90	447	453	6
1988-89	361	395	34	1987-88	418	426	8	1989-90	450	460	10
1990-91	386	390	4	1988-89	418	426	8	1988-89	451	453	2
1989-90	386	405	19	1987-88	418	429	11	1990-91	452	455	3
1990-91	388	395	7	1990-91	418	432	14	1988-89	454	466	12
1990-91	388	425	37	1990-91	418	434	16	1989-90	455	458	3
1987-88	390	416	26	1987-88	420	421	1	1990-91	460	464	4
1989-90	391	418	27	1989-90	420	422	2	1987-88	462	463	1
1987-88	392	409	17	1990-91	420	429	9	1988-89	463	478	15

Appendix A7. Lake trout captured, marked, and recaptured in Sevenmile Lake with estimates of abundance, survival and recruitment from the Jolly-Seber model, 1987 - 1991.

	Year				
Number of Lake Trout	1987	1988	1989	1990	1991
Originally marked in 1987	0	25	20	25	17
Originally marked in 1988		0	18	14	20
Originally marked in 1989			0	20	25
Originally marked in 1990				0	31
Captured with tags	0	25	38	59	93
Captured without tags	198	136	119	196	221
Total captured	198	161	157	255	314
Released with tags	196	158	150	246	312
Released without tags	0	5	0	0	0
Total Released	196	158	150	246	312
Abundance estimate	--	1,262	1,435	2,305	--
SE of abundance estimate	--	198	196	312	--
Lake trout per hectare	--	38.2	43.4	69.8	--
Survival rate estimate	--	1	1	1	--
SE of survival estimate	--	0	0	0	--
Recruitment estimate	--	--	176	878	--
SE of recruitment estimate	--	--	215	351	--

APPENDIX B
(Questionnaire Letter and Questionnaire)

Appendix B1. Questionnaire letter.

Dear Angler,

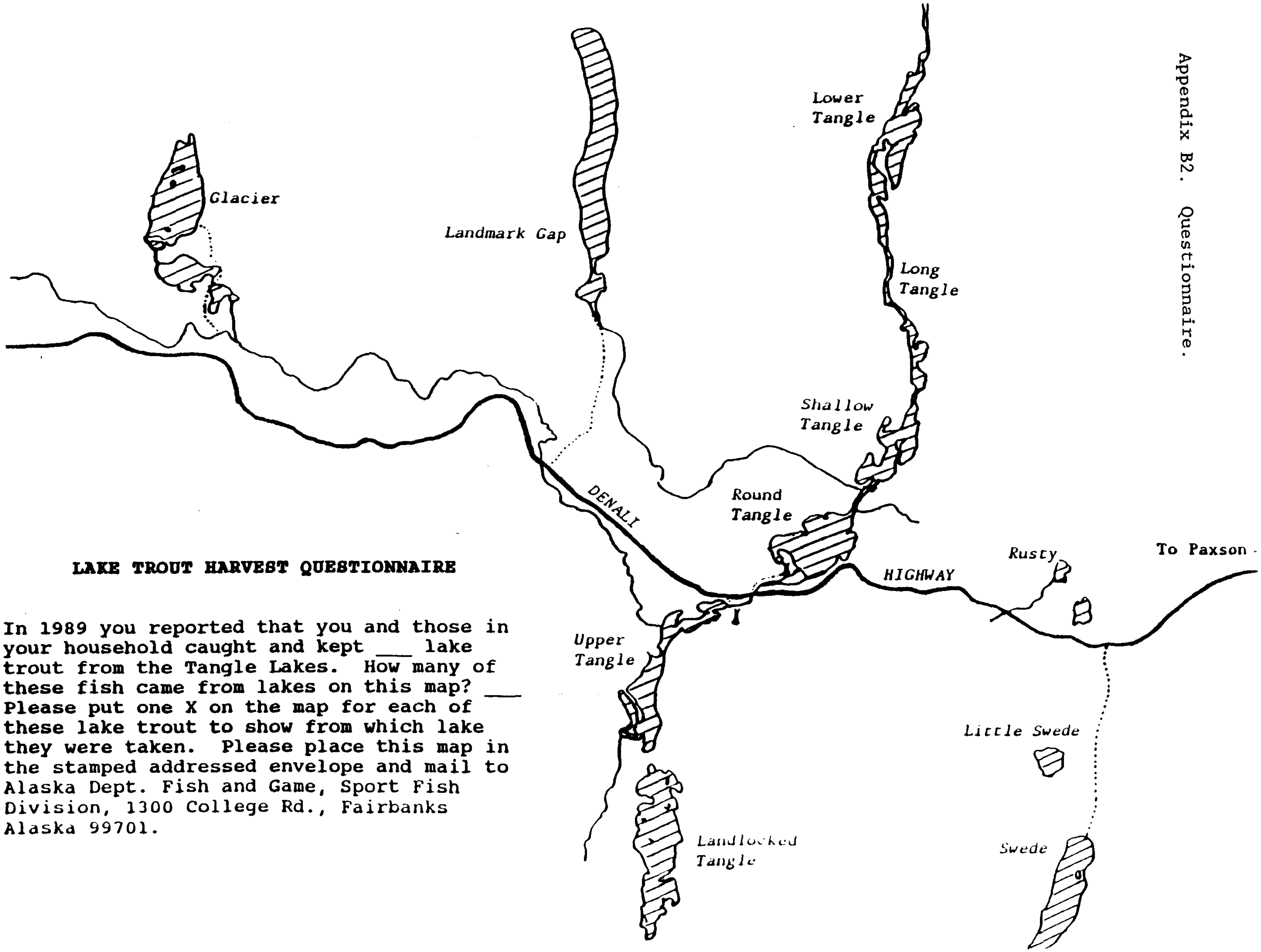
Sport Fish Division of the Alaska Department of Fish and Game is conducting research on lake trout fishing in the Tangles Lakes area. The purpose of this study is to find out where within the Tangle Lakes area lake trout are most often caught. Your name was selected from a list of anglers who answered the Statewide Harvest Survey and listed harvesting lake trout from the Tangle Lakes.

The attached questionnaire asks you to mark on the map the lake(s) from which members of your household caught and kept lake trout during 1989. Please take a couple of minutes now to complete this questionnaire. Your answers are very important. We need this information to manage the lake trout populations in the Tangle Lakes. Your individual answers will be kept confidential. Only summary information will be made public.

If you have any questions or comments concerning this survey, please contact me. Thank you for your help in managing our fishery resource.

Sincerely,

John Burr
Fishery Biologist
Sport Fish Division
(907) 456-8819



LAKE TROUT HARVEST QUESTIONNAIRE

In 1989 you reported that you and those in your household caught and kept ___ lake trout from the Tangle Lakes. How many of these fish came from lakes on this map? ___ Please put one X on the map for each of these lake trout to show from which lake they were taken. Please place this map in the stamped addressed envelope and mail to Alaska Dept. Fish and Game, Sport Fish Division, 1300 College Rd., Fairbanks Alaska 99701.